Journal of Forensic and Legal Medicine 20 (2013) 300–304

Contents lists available at SciVerse ScienceDirect

Journal of Forensic and Legal Medicine

journal homepage: www.elsevier.com/locate/jflm

Original communication

Estimation of blood alcohol concentration in deaths due to roadside accidents

Puneet Arora MBBS, MD Ex-Resident, Instructor [a,b,c,*], Ashok Chanana MD, DNB Associate Professor [a], Hakumat R. Tejpal MBBS, MS Additional Professor (Retd.) [a]

[a] Department of Forensic Medicine and Toxicology, Government Medical College, Amritsar, India
[b] Biology Department, College of New Caledonia, Prince George, Canada
[c] Department of Community & Health Studies, Mount Royal University, Calgary, Canada

ARTICLE INFO

Article history:
Received 22 June 2012
Received in revised form
15 September 2012
Accepted 26 December 2012
Available online 16 January 2013

Keywords:
Blood alcohol concentration
Roadside accidents
Autopsy

ABSTRACT

Like any other disease, accidents too are caused by interaction between agent, host, and environment. Human factors include age, (accidents most common between 10 and 24 years), sex, education, medical conditions (heart attack, impaired vision), fatigue, influence of alcohol and other drugs, lack of bodily protection (like helmets, seat belts) and psychosocial factors like lack of experience, impulsiveness, aggressiveness, defective judgment and delay in decisions. Drunken driving is an important risk factor in causing accidents. This study was focused on the status of alcohol consumption in relation with roadside accidents in northern India in the region of Amritsar. The present study was carried out in 100 cases alleged to have died of roadside accident and brought to the mortuary attached to the Department of Forensic Medicine and Toxicology, Government Medical College, Amritsar for autopsy examination. Blood samples were collected from the femoral vein and were tested for the presence of alcohol with steam distillation and titration method using potassium dichromate and sulfuric acid. In the present study, 23% of the fatal driver/pedestrian victims of roadside accidents were found to have consumed alcohol before accident. Most of the victims of road accident were from the age group 21–30 and 31–40 years. Most of the accidents occurred on straight roads instead of bends or intersections, more during daytime and weekends. 57% of the blood alcohol positives were between 100 mg% and 149 mg%. Majority of the victims of roadside accidents were motorcyclists and the striking vehicles were trucks and buses causing head & neck injuries in most of the victims. Death occurred within a few minutes in most of the cases.

1. Introduction

Alcoholism or Dependent drinking; practically is persistent drinking that interferes with the person's health, legal position, interpersonal relationships, or means of livelihood.[1] In Western countries 90 percent of people drink alcohol. 40–50 percent of men have temporary alcohol induced problems (alcohol dependence or abuse-alcoholism.)[2] In U.K., the adult population is 43 million; out of which 36 million are regular drinkers, 4 million are heavy drinkers, 0.8 million problem drinkers and 0.4 million are dependent drinkers. In USA, it is the third largest health problem, reducing life expectancy by 12 years, causing serious problems in 1 million drinkers, associated with ½ million hospital admissions and with 40% road traffic accidents.[1]

A Road Traffic crash is defined as a collision or incident that may or may not lead to injury, occurring on a public road and involving at least one moving vehicle. Throughout the world, roads are bustling with cars, buses, trucks, motorcycles and other types of two and three wheelers. India has one of the largest highway and road network second only to road network of U.S. Of the worldwide average of 700,000 RTA, 10% are in India. The latest annual statistics indicate over 80,000 are killed on Indian roads.[3] An Indian estimate shows that 25% of RTA are alcohol related. Alcohol causes poor judgment, slowed reaction time, loss of concentration and impaired vision.[3]

The National Highway Transportation Safety Administration, USA has now chosen the term "crash" not "accident", suggesting that most accidents are not "accidental".[4] Human error is the sole cause in 57% of all road accidents and is a contributing factor in over 90%. It is suggested that alcohol might influence the specific type of injury.[5] According to National Institute on Alcohol Abuse and

Abbreviations: BAC, blood alcohol concentration; RSA, roadside accident.

* Corresponding author. Present address: Biology Department, College of New Caledonia, 1382 Garvin Street, Prince George, BC V2M 3Y8, Canada. Tel.: +1 250 981 8052.
E-mail address: arorapuneet@live.com (P. Arora).

1752-928X/$ – see front matter © 2013 Elsevier Ltd and Faculty of Forensic and Legal Medicine. All rights reserved.
http://dx.doi.org/10.1016/j.jflm.2012.12.003

Alcoholism at least 700 driving accidents a year involve spinal cord injuries to the neck, and as many as half of those involve alcohol.[6] Cut off level of blood alcohol in drivers in USA is 100 mg%, UK 80 mg%, Australia 50 mg%, Germany 80 mg% and France 50 mg%.[7] According to Sec.185, Motor vehicle act, 1988, the statutory limit of BAC in India is 30 mg%.[8]

The present study was carried out in 100 cases alleged to have died of roadside accident. This study was aimed at finding blood alcohol concentration (BAC) in people dying in roadside accidents (RSA). The study recorded consumption of alcohol in terms of blood alcohol concentration, the injury pattern and cause of death in drivers/pedestrians who died in roadside accident and highlighted other factors, which in combination with alcohol provoked road accidents.

2. Materials and methods

The present study was carried out in 100 cases between November 2005 and October 2007 alleged to have died of roadside accident and brought to the mortuary attached to the Department of Forensic Medicine and Toxicology, Government Medical College, Amritsar for autopsy examination.

In this study, we chose 100 male victims died of roadside accidents who were also the drivers of various vehicles at the time of accident. The second category of the subjects chosen was the pedestrians. In addition, we selected only those cases that died on the spot after the accident or on the way to hospital. The victims who died after hospital admission were ignored for this study. All the cases were first thoroughly examined especially the injuries and their pattern. The cause of death was confirmed at autopsy. Blood samples were collected from the femoral veins; or from right side of heart, in cases the same was not available from femoral veins. We collected 5 ml of blood in a clean dry vial containing about 10 mg of sodium fluoride as preservative and anticoagulant. The sample was preserved in refrigerator and tested for alcohol concentration within twenty-four hours of collection.

The present study was carried out by using Steam Distillation and Titration method using potassium dichromate and sulfuric acid.[9]

3. Results

The 100 male drivers of different vehicles who died of roadside accidents or the pedestrians were examined for injuries, epidemiological findings, and BAC. The following statistics were recorded in this study.

3.1. Blood alcohol positives (Table 1)

Out of the total 100 cases tested for blood alcohol concentration 23% cases were found to be positive for alcohol while the other 77% cases were found negative for blood alcohol.

3.2. Age group of victims (Table 2)

Out of the total 100 RSA cases examined for BAC, the age-wise distribution of alcoholics as well as non-alcoholics at the time of accident is shown in Table 2. Twenty-five percent of the victims of roadside accident were from the age group of 21 to 30 years and 29% from the age group 31 to 40 years. Amongst these, a major group of blood alcohol positives was from the age group 21 to 30 years (39%).

Table 1
Blood alcohol positives.

Total no. of cases	BAC +s	BAC −s
100	23	77

BAC +s: Blood alcohol concentration; positives.
BAC −s: Blood alcohol concentration; negatives.

Table 2
Age group of victims.

Sr. No.	Age group (in years)	Total RSA deaths	BAC +s (Total 23)	Percentage among BAC +s
1	<20	12%	–	–
2	21–30	25%	09	39%
3	31–40	29%	05	22%
4	41–50	11%	07	30%
5	51–60	10%	02	09%
6	>60	13%	–	–

RSA: Roadside accident.
BAC +s: Blood alcohol concentration; positives.

3.3. Place of accident (Table 3)

Out of the total 100 cases examined for blood alcohol positives, a total of 70% accidents occurred on straight roads, 21% occurred on bends while 9% on intersections. Amongst these 74% of the total blood alcohol positives were involved in accidents on straight roads, 22% were involved in accidents on bends and only 4% accidents were on intersections.

3.4. Blood alcohol concentration (BAC) (Table 4)

Fifty-seven percent of the total alcohol positive individuals showed BAC from 100 to 149 mg%, 30% individuals had shown BAC between 50 and 99 mg% and more than 13% individuals were found to be 150 mg% or more.

3.5. Day of the week (Table 5)

Considering the first day of the week from Monday, 23% of road accidents occurred on Wednesdays, 17% on Mondays, 15% on Saturdays, 14% on Sundays and 13%, 11%, & 7% on Thursdays, Fridays, and Tuesdays respectively. Among the alcohol positive group 30% accidents occurred on Saturdays and 26% on Sundays. There were no BAC positives on Tuesdays and minimal (13%) on Thursdays.

3.6. Vehicle with the occupant (Table 6)

In 39% of the total 100 cases studied, the victim was the occupant of a motorcycle. Others were bicyclists in 17% cases, scooter drivers in 16% cases and pedestrians in 14% cases. Nine percent of the occupants were driving the cars.

3.7. Striking vehicle (Table 7)

The casualties occurring in 100 road accident cases were as a result of striking with Trucks and Buses in 28% and 27% cases respectively. Cars were the striking vehicles in 19% cases. Twelve

Table 3
Place of accident.

Sr. No.	Place of accident	Total RSA deaths	BAC +s (Total 23)	Percentage among BAC +s
1	Straight road	70%	17	74%
2	Bend	21%	05	22%
3	Intersection	09%	01	4%

RSA: Roadside accident.
BAC +s: Blood alcohol concentration; positives.

Table 4
Blood alcohol concentration (BAC).

Sr. No.	Blood alcohol conc. (BAC)	No. of individuals	Percentage
1	50–99 mg%	07	30%
2	100–149 mg%	13	57%
3	>150 mg%	03	13%

BAC: Blood alcohol concentration.

percent of the deceased had fallen themselves without striking with other vehicles. Amongst these individuals, 58% were found to be blood alcohol positive. Other striking vehicles were tractor trolleys and motorcycles (9% and 4% respectively). In one case, the striking vehicle was unknown.

3.8. Body parts injured (Table 8)

Out of the total 100 cases studied, it was found that head & neck injury was seen in 74% victims. Face, chest, abdomen and extremities were injured in 58%, 55%, 35%, and 93% of the individuals respectively. Considering blood alcohol positive individuals at the time of accident, it was noted that head & neck was injured in 91% victims. Face, chest, abdomen and extremities were injured in 87%, 65%, 39%, and 100% of the individuals respectively.

3.9. Time between injury and death (Table 9)

Out of the 100 cases of deaths due to RSA, 63% of the people died within minutes after the accident, 20% died immediately and 17% died within few hours after the accident. Amongst these, the figures for blood alcohol positives were 65% for those who died within minutes, 22% for those who died immediately and 13%, for those who died within few hours after the accident.

3.10. Cause of death (Table 10)

Of the total 100 cases examined, 48% of the individuals died due to intracranial hemorrhages, 17% were led to death by laceration of brain, 15% died due to hemorrhage and shock from blood loss. Remaining 10% and 9% died due to abdominal organ injury and thoracic organ injury respectively. In 1% of the cases, the cause of death was neurogenic shock due to testicular injury. Amongst the blood alcohol positives, the cause of death was cerebral compression in 61% cases and laceration of brain in 26% cases. Thoracic and abdominal injury was responsible for death in 9% and 4% individuals respectively.

4. Discussion

Out of the 100 cases studied, 23% cases were found to be positive for blood alcohol. According to a WHO report an Indian estimate shows 25% of RTA to be alcohol related.[10] Wyss et al. noted that there was a 21% incidence of alcohol intoxication (BAC greater than = 80 mg%) amongst 167 consecutive traffic accident victims.[11] Chen et al. explored in their study of 381 persons involved in traffic accidents that 21% had detectable blood alcohol concentrations.[12] From all these studies it is evident that alcohol consumption is a major attributable cause in road accidents in any region of the world. Most of the victims from alcohol positive group were of the age group 21–30 years i.e. 39%. Similar trend had been shown by Chandra et al., in which most common (27.38%) age group involved was 21–30 years, followed by 31–40 years age group (18.63%).[13] The place of occurrence of accident in this study was found to be majority on straight roads in 70% cases, at the bends in 21% cases and only 9% at the intersections. Discussing the scenario amongst alcoholic related accident deaths the figures increased slightly in cases of straight road accidents i.e. 74%, remained almost same in cases of accidents at the bends i.e. 22% while decreased slightly to 4% in cases of accidents at intersections. Mustafa documented in his overview that most (63%) of the accidents were reported on straight roads, followed by 20% at bends and 17% at intersections.[14] These figures indicate that it's the human error, which is the biggest agent in the causation of a roadside accident rather than mechanical fault or environment factors.

Estimating the concentration of alcohol in the blood of deceased, it was found that 57% of cases showed concentration between 100 and 149 mg%. Thirty percent of the cases showed blood alcohol concentration between 50 and 99 mg% and 13% cases ended up showing more than 150 mg%. Bernini et al. noticed in their study of fatal accidents in Brescia that amongst blood alcohol positive causalities, majority (48%) were showing BAC less than 100 mg%, 28% were showing BAC between 101 and 200 mg% and the other 24% had BAC more than 200 mg%.[15] It is understandable that although "alcohol-type" crash characteristics e.g. Inattention appears at concentration as low as 20–40 mg%, most of the crashes were observed at BAC 50–149 mg% in the present study and in all the similar studies. The American Medical Association (AMA) Council on Scientific Affairs in 1986 reviewed the existing literature on drinking and driving and reached the conclusions that driving impairment begins at a blood alcohol concentration (BAC) level of 50 mg% or even lower while serious driving impairment occurs at a BAC of 100 mg%. Drivers with BAC of 50 mg% to 100 mg% are significantly represented in fatal motor

Table 5
Day of the week.

Sr. No.	Day of the week (Starting from Monday)	Total RSA deaths	BAC +s (Total 23)	Percentage among BAC +s
1	1st	17%	4	18%
2	2nd	7%	–	–
3	3rd	23%	3	13%
4	4th	13%	3	13%
5	5th	11%	–	–
6	6th	15%	7	30%
7	7th	14%	6	26%

RSA: Roadside accident.
BAC +s: Blood alcohol concentration; positives.

T able 6
Vehicle with the occupant.

Sr. No.	Vehicle with the occupant	Total RSA deaths	BAC +s (Total 23)	Percentage among BAC +s
1	Pedestrian	14%	2	9%
2	Bicycle	17%	1	4%
3	Scooter	16%	8	35%
4	Motorcycle	39%	10	43%
5	Bullock cart	01%	–	–
6	Threewheeler	04%	–	–
7	Car	09%	2	9%

RSA: Roadside accident.
BAC +s: Blood alcohol concentration; positives.

Table 7
Striking vehicle.

Sr. No.	Striking vehicle	Percentage
1	Fallen itself	12%
2	Motorcycle	04%
3	Car	19%
4	Tractor trolley	09%
5	Bus	27%
6	Truck	28%
7	Unknown	01%

Table 8
Body parts injured.

Sr. No.	Body parts injured	Total victims showing injury (Out of 100)	Percentage	BAC +ve victims showing injury (Total 23)	Percentage
1	Head & neck	74	74%	21	91%
2	Face	58	58%	20	87%
3	Chest	55	55%	15	65%
4	Abdomen	35	35%	09	39%
5	Extremities	93	93%	23	100%

BAC +s: Blood alcohol concentration; positives.

vehicle crash statistics and biological differences among humans regarding alcohol influence and alcohol tolerance make it virtually impossible to specify any "safe" level of drinking and driving.[16]

It was observed in the present study that most of the alcohol positive victims were involved in fatal accidents on weekends i.e. Saturdays (30%) and Sundays (26%). Keall and Patterson did a research work to show that, given the levels of drinking and driving on weekend nights, the overall effect of alcohol was shown to contribute almost half of weekend night time risk for drivers.[17] Hingson and Winter analyzed in a study that more alcohol-related fatal crashes occurred on Saturday (24%) than any other day, followed by Sunday (21%) and Friday (16%).[18] The reasons to support the above findings could be the drinking patterns i.e. more prevalence of drinking on weekends added by the fact that Sunday being holiday, some elation of mood is mostly present on weekend. Similarly, due to some cultural beliefs or superstitions, people in this region do not drink alcohol on Tuesdays and Thursdays, speaking in favor of the findings of nil or minimum alcohol positive crashes.

The observations in the present study showed that most of the accidents whether alcohol related or non-alcohol related had a high involvement of motorcyclists (43% & 39%) and scooter drivers (35% & 16%). Hingson and Winter observed that 44% of motorcycle deaths were alcohol related.[18] These studies show that pedestrians or motorized two-wheeler drivers are the commonest victims in road accidents either alcohol related or others, with some regional variations depending upon the prevalence of type of vehicle used by people of different communities for daily purposes. In our region, motorcyclists are the main bulk of road occupants as well as road accidents.

Most of the striking vehicles were buses and trucks as noted in this study. The figures were 27% and 28% respectively. Kaul et al. found that heavy vehicles (trucks, oil tanker, lorries, bus etc) were mostly responsible for 58.52% of cases followed by light vehicles (car, jeep, van, taxies) 21.58% of fatal RTA.[19] These observations can be attributed to the high speed and momentum of such vehicles, presence of single space roads, driver's fatigue, drinking alcohol etc. It was observed that 74% of the victims suffered a head & neck injury. Honkanen and Smith recorded that head injury was more common among the intoxicated (64.1 percent) than among the sober (17.6 percent) victims of traffic accidents.[20]

The above patterns of injuries show that alcohol related falls are more often associated with severe craniofacial injury. This may be due to the facts that alcohol produces mostly low-energy events like falls, resulting usually in minor, though potentially dangerous head injury. In other words, the part of body above the center of gravity lies in greater momentum than the lower part during sudden deceleration. In addition, the increased likelihood of craniofacial injury is probably due in part to the fact that the rate of helmet and other restraints use at the time of injury among the intoxicated is much lower than among the sober.

Table 9
Time between injury and death.

Sr. No.	Time between injury & death	Total RSA deaths	BAC +s (Total 23)	Percentage among BAC +s
1	Immediate	20%	05	22%
2	Within minutes	63%	15	65%
3	Within few hours	17%	03	13%

RSA: Road-side accident.
BAC +s: Blood alcohol concentration; positives.

Table 10
Cause of death.

Sr. No.	Cause of death	Total RSA deaths	BAC +s (Total 23)	Percentage among BAC +s
1	Intracranial hemorrhages	48%	14	61%
2	Laceration of brain	17%	06	26%
3	Injury to thoracic organs	09%	02	9%
4	Injury to abdominal organs	10%	1	4%
5	Hemorrhage & shock	15%	–	–
6	Testicular injury	01%	–	–

RSA: Road-side accident.
BAC +s: Blood alcohol concentration; positives.

It was found in this study that most of the individuals died within few minutes after the accident (63%) followed by deaths occurring immediately (20%). In alcohol related deaths, the numbers increased a bit i.e. 65% for deaths within minutes and 22% for immediate deaths. Zink et al. noted in a study that 61.8% of accident victims of alcohol positive group died with time to death less than 1 h (odds ratio 1.62). When they combined the alcohol positives with central nervous system injury cases, found that 67.1% had died with time to death less than 1 h (odds ratio 2.04).[21] Considering the facts that most of the injured persons who died immediately or within few minutes of accident in both alcohol positive and negative group were associated with the involvement of head & neck, it is suggestive of the reason of early deaths in roadside accident victims. The cause of death in the present study was found to be brain compression due to intracranial hemorrhages in majority of subjects i.e. 48% followed by laceration of brain in 17% subjects. McCoy reviewed the records of 131 road accident fatalities in Oxfordshire and noted that deaths were mainly due to cerebral injury (34.4 percent) or uncontrollable (mainly thoracic) hemorrhage (25.2 percent).[22] The findings regarding cause of death in the present study and the other studies had shown a high percentage of cranial injury leading to fatality in road accident cases.

5. Conclusions

After consumption of alcohol, one forgets to take necessary precautions while driving a vehicle, may be due to over confidence, i.e. wearing a helmet or tying a seat belt etc. This is the reason why incidence of head injury especially in motorcyclists was highest in the present study.

From the present study, it can be concluded that:

1. Consumption of alcohol has a significant influence on the incidence of fatal road traffic accidents.
2. Mostly young people of early adulthood age group are the victims of fatal alcohol positive roadside accidents.
3. Most of the accidents occur on straight roads rather than bends or intersections concluding the fact that human error is the major factor leading to road accidents rather than environmental factors.
4. Motorcyclists are the main victims of road accidents and trucks and buses are the main striking vehicles in both alcohol positive and negative groups.
5. Head and neck are the most common body regions injured leading to compression of brain as the leading cause of death within few minutes of accident especially in alcohol related crashes.

Ethical approval

An approval was obtained from the Institutional Ethics Committee before taking up the research work.

Funding

None.

Conflict of interest

None.

References

1. Naik P, Lawton J. Assessment and management of individuals under the influence of alcohol in police custody. *J Clin Forensic Med* 1996;**3**:37–44.
2. Aschukit M. *Alcohol and alcoholism*. In: *Harrison's principles of internal medicine*. 14th ed., vol. 2. New York: McGraw Hill; 1998. p: 2503, 2505.
3. Pirabu D. *WHO world report on road traffic accidents*. Available at URL: http://www.icm.tn.gov.in/seminar/rta.htm [accessed 16.06.07].
4. Russell J. *June Russell's health facts, overview, alcohol-accidents*. Available at URL: http://www.jrussellshealth.com/alcacc.html [accessed 29.07.05].
5. Li G, Keyl PM, Smith GS, Baker SP. Alcohol and injury severity; reappraisal of the continuing controversy. *J Trauma* 1997;**42**:562–9.
6. Russell J. *Washington post health*. Available at URL: http://www.jrussellshealth.com/index.html; Aug 1994 [accessed 01.08.05].
7. Raina A, Shrivastava HC, Dogra TD. Reliability factor of different breath analyzer and its co-relation with blood alcohol concentration GLC – a pilot study. *Indian Internet J Forensic Med Toxicol* 2003;**1**(1).
8. Reddy KSN. *The essentials of forensic medicine and toxicology*. 20th ed. Hyderabad: MB Company; 2005. p. 484.
9. Zadour P. Alcohol-related relative risk of fatal driver injuries in relation to driver age and sex. *J Stud Alcohol* 1991;**52**(4):302–10.
10. Dass KC. An epidemiological study of road traffic accident victims in medicolegal autopsies. *J Indian Acad Forensic Med* 2005;**27**(3).
11. Wyss D, Rivier L, Gujer HR, Paccaud F, Magnenat P, Yersin B. Characteristics of 167 consecutive traffic accident victims with special reference to alcohol intoxication: a prospective emergency room study. *Soz Praventivmed* 1990;**35**(3):108–16.
12. Chen SC, Lin FY, Chang KJ. Body region prevalence of injury in alcohol- and non-alcohol-related traffic injuries. *J Trauma* 1999 Nov;**47**(5):881–4.
13. Chandra J, Dogra TD, Dikshit PC. Pattern of craniointracranial injuries in fatal vehicular accidents in Delhi, 1966–76. *Med Sci Law* 1979;**19**(3):186–94.
14. Mustafa MN. *Overview of current road safety situation in Malaysia*. Available at URL: http://www.unescap.org/ttdw/common/TIS/AH/files/egm06/roadsafety_malaysia.pdf [accessed 02.09.07].
15. Bernini M, et al. *Alcohol, drugs and fatal accidents in Brescia and the Italian highway code regulations*. Available at URL: http://www.druglibrary.org/schaffer/Misc/driving/s30p12.htm [accessed 10.05.07].
16. Miller TR. Alcohol and the driver. Council on Scientific Affairs. *J Am Med Assoc* 1986;**255**(4):522–7.
17. Keall MD, Patterson TL. The contribution of alcohol to night time crash risk and other risks of night driving. *Accid Anal Prev* 2005 Sep;**37**(5):816–24.
18. Hingson R, Winter M. Epidemiology and consequences of drinking and driving. *Alcohol Res Health* 2003;**27**(1):63–78.
19. Kaul A, Sinha US, Kapoor AK, Pathak YK, Sharma S, Singh A, et al. An epidemiological study of fatal road traffic accidents in Allahabad region. *Indian Internet J Forensic Med Toxicol* 2005;**3**(1).
20. Honkanen R, Smith G. Impact of acute alcohol intoxication on patterns of non-fatal trauma: cause-specific analysis of head injury effect. *Injury* 1991 May;**22**(3):225–9.
21. Zink BJ, Maio RF, Chen B. Alcohol, central nervous system injury, and time to death in fatal motor vehicle crashes. *Alcohol Clin Exp Res* 1996 Dec;**20**(9):1518–22.
22. McCoy GF. A review of fatal road accidents in Oxfordshire over a 2-year period. *Injury* 1989 Mar;**20**(2):65–8.